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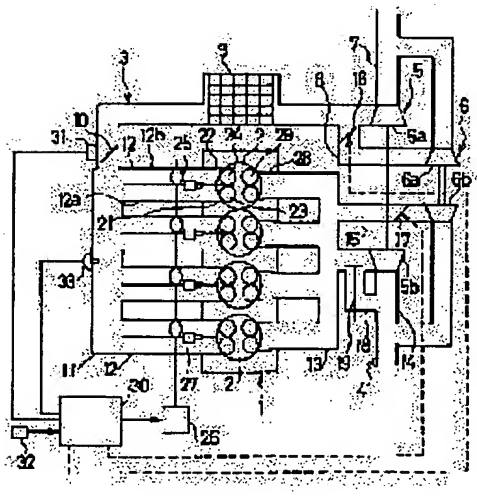
(54) ENGINE PROVIDED WITH TURBO SUPERCHARGER



(57)Abstract:
PURPOSE: To achieve torque-up through supercharging under a condition that a knocking inhibition effect is improved through the delay closing of an intake valve at least at a low-speed region, to reduce NOx by appropriate internal EGR even under a supercharged condition, and to prevent increase in the reverse flow of exhaust.
CONSTITUTION: Primary and secondary turbo superchargers 5, 6 are provided as superchargers, and intake valve closing timing is determined at 65°-100° after the bottom dead center, so that no less than 1/3 of the range up to a maximum torque in a low-speed region is occupied by a supercharged region, while valve opening overlap of intake and exhaust valves is set to no more than 20°. An internal EGR is thus obtained, while reverse flow of exhaust is not increased.

CLAIMS

[Claim(s)]
[Claim 1] In the engine set up so that an engine geometric compression ratio might be made or

more into 8.5, and an inhalation-of-air valve-closing time term might be made late and an effective compression ratio might become smaller than an expansion ratio, while it had a supercharger While setting up so that a turbosupercharger may be used for the above-mentioned supercharger, an inhalation-of-air valve-closing time term may be made into 65 degrees - 100 degrees behind a bottom dead point and a supercharge region may occupy 1/3 or more [of the range from torque 0 to the maximum torque] in a low-speed area at least The turbo supercharged engine characterized by setting valve-opening overlap of an intake/exhaust valve as 20 degrees or less.

[Claim 2] The turbo supercharged engine [equipped with the turbosupercharger for low speeds which operates by the low-speed area at least, and the turbosupercharger for high speeds which operates in a high-speed region] according to claim 1.

[Claim 3] The turbo supercharged engine according to claim 1 or 2 which enlarged valve-opening overlap of an intake/exhaust valve in the high-speed region compared with the low-speed area.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] Its geometric compression ratio is high while this invention is equipped with a turbosupercharger, and an inhalation-of-air valve-closing time term is related with the engine made late.

[0002]

[Description of the Prior Art] From the former, by supercharging inhalation of air by the mechanical supercharger or the turbosupercharger, the fill of inhalation of air is increased and, generally the supercharged engine which raised engine torque is known. The technique which aimed at the torque rise by supercharge where knocking is controlled is proposed by making an inlet valve into ****** especially recently.

[0003] for example, in JP,63-195325,A In the engine equipped with the supercharger and the intercooler, while making an engine geometric compression ratio into 8.5 or more high compression ratios By making an effective compression ratio smaller than an expansion ratio, and reducing compression top dead center temperature, improving thermal efficiency and earning an expansion ratio by delaying the closed stage of an inlet valve beyond a predetermined value from a bottom dead point Knocking in a low-speed heavy load region etc. is controlled, and the supercharged engine which raises a supercharge operation of a supercharger and aimed at the torque rise in this condition is shown. Any of a turbosupercharger and a mechanical supercharger can also be used for a supercharger in this supercharged engine.

[0004]

[Problem(s) to be Solved by the Invention] By the way, in order to raise knocking depressant action in a low-speed heavy load region etc. and to aim at a torque rise effectively, it is desirable to enlarge the degree of ****** of an inlet valve, but if it does in this way, a supercharge region will be expanded to a common operation region side. And since a MAP becomes higher than exhaust gas pressure in a supercharge region and internal EGR is not obtained when a

mechanical supercharger is used as a supercharger, if a supercharge region is expanded to a common operation region, the problem of NOx increase in a common operation region will arise. When a turbosupercharger is used compared with this, since exhaust gas pressure becomes high and internal EGR arises also in a supercharge region, it becomes advantageous in respect of NOx reduction, but if the back flow of exhaust air increases during valve-opening overlap of an intake/exhaust valve, it will become disadvantageous in torque.

[0005] This invention is in the condition which raised the knocking depressant action by ****** of an inlet valve by the low-speed area at least in view of the above-mentioned situation, and it aims at offering the turbo supercharged engine which can attain a supercharge **** torque rise effectively, and can moreover aim at reduction of NOx in a common engine-speed region, and can prevent increase of a back flow of exhaust air.

[0006]

[Means for Solving the Problem] In the engine set up so that an engine geometric compression ratio might be made or more into 8.5, and an inhalation-of-air valve-closing time term might be made late and an effective compression ratio might become smaller than an expansion ratio, while this invention was equipped with a supercharger, in order to attain the above-mentioned purpose While setting up so that a turbosupercharger may be used for the above-mentioned supercharger, an inhalation-of-air valve-closing time term may be made into 65 degrees - 100 degrees behind a bottom dead point and a supercharge region may occupy 1/3 or more [of the range from torque 0 to the maximum torque] in a low-speed area at least Valve-opening overlap of an intake/exhaust valve is set as 20 degrees or less.

[0007] In this turbo supercharged engine, it is desirable to have the turbosupercharger for low speeds which operates by the low-speed area at least, and the turbosupercharger for high speeds which operates in a high-speed region.

[0008] Moreover, it is desirable to enlarge valve-opening overlap of an intake/exhaust valve in a high-speed region compared with a low-speed area.

[0009] In addition, the inhalation-of-air valve-closing time term in the above-mentioned configuration and valve-opening overlap make the time of an inlet valve closing to the amount of lifts of 0mm on the basis of 0mm lift an inhalation-of-air valve-closing time term, and are considering during the time of the time of an inlet valve beginning to open from the amount of lifts of 0mm and an exhaust valve closing to the amount of lifts of 0mm as valve-opening overlap.

[0010]

[Function] The torque rise by supercharge is achieved an effective compression ratio being moderately lowered by an inhalation-of-air valve-closing time term being delayed greatly, and knocking being controlled by this, while according to the turbo supercharged engine of this invention thermal efficiency is raised by a geometric compression ratio being made into a high compression ratio and an expansion ratio is earned. And by using the turbosupercharger, although a supercharge region is expanded to a common operation region by considering as the above conditions by the low-speed area at least, valve-opening overlap of an intake/exhaust valve is adjusted so that internal EGR may be obtained also in a supercharge region and the back flow of exhaust air may not increase.

[0011] If both the turbosuperchargers the object for low speeds and for high speeds are used as a turbosupercharger, the above-mentioned operation will be demonstrated good by raising the supercharge response in a low-speed area.

[0012] If valve-opening overlap of an intake/exhaust valve is enlarged in a high-speed region

compared with a low-speed area, it will become advantageous to a torque rise in a high-speed region etc.

[0013]

[Example] The example of this invention is explained based on a drawing. Drawing 1 shows the turbo supercharged engine by one example of this invention. In this drawing, 1 is the engine equipped with two or more gas columns 2, and that geometric compression ratio is 8.5 or more high compression ratios. The turbosupercharger is prepared while the inhalation-of-air path 3 and a flueway 4 are arranged to this engine 1. The primary turbosupercharger (turbosupercharger for low speeds) 5 which especially operates according to a low-speed area at least in this example, and the secondary turbosupercharger (turbosupercharger for high speeds) 6 which operates in a high-speed region are formed. Each above-mentioned turbosuperchargers 5 and 6 have the compressors 5a and 6a in an inhalation-of-air path, and the turbines 5b and 6b in a flueway, and when Compressors 5a and 6a rotate with the drive of the turbines 5b and 6b by exhaust gas, they supercharge inhalation of air, respectively. The high thing of the supercharge response in a low-speed area is used for the above-mentioned primary turbosupercharger 5. And only the primary turbosupercharger 5 operates in a low-speed area, and both the turbosuperchargers 5 and 6 operate in a high-speed region.

[0014] That is, the primary inhalation-of-air path 7 which passes along compressor 5a of the primary turbosupercharger 5, and the secondary inhalation-of-air path 8 which passes along compressor 6a of the secondary turbosupercharger 6 are formed in the upstream part of the inhalation-of-air path 3, and these inhalation-of-air paths 7 and 8 join it on the lower stream of a river of Compressors 5a and 6a. An intercooler 9 and a throttle valve 10 are interposed in the down-stream inhalation-of-air path 3 from this unification section, and the inlet manifold 11 which has the independent inhalation-of-air path 12 according to gas column is further formed in that lower stream of a river. On the other hand, the primary flueway 14 which leads exhaust air to turbine 5b of the primary turbosupercharger 5, and the secondary flueway 15 which leads exhaust air to turbine 6b of the secondary turbosupercharger 6 are formed in the lower stream of a river of an exhaust manifold 13 in juxtaposition, and these flueways 14 and 15 join the flueway 4 on the lower stream of a river of Turbines 5b and 6b.

[0015] The shutter valves 16 and 17 are formed in the above-mentioned secondary inhalation-of-air path 8 and the secondary flueway 15, respectively, and these shutter valves 16 and 17 operate by the driving means outside drawing with the after-mentioned control unit 30. And in a low-speed area, both the turbosuperchargers 5 and 6 operate by closing the shutter valves 16 and 17 by stopping the secondary turbosupercharger 6, and only the primary turbosupercharger's 5 operating, and opening the above-mentioned shutter valves 16 and 17 in a high-speed region. The waist gate path where 18 bypasses turbine 5b, and 19 are waist gate valves which open this waist gate path 18 and adjust charge pressure, when charge pressure is beyond a predetermined value.

[0016] The suction port which carries out opening is formed in the combustion chamber at the downstream of each independent inhalation-of-air path 12 of the above-mentioned inlet manifold 11. In this example, two suction ports, the 1st and the 2nd, 21 and 22 are formed to a combustion chamber, and it is divided into 1st path 12a and 2nd path 12b with which the independent inhalation-of-air path 12 is connected in these suction ports 21 and 22. Inlet valves 23 and 24 are formed in both the above-mentioned suction ports 21 and 22, respectively. Moreover, the closing motion valve 25 which operates with 12b and an actuator 26, and opens and closes this path 12b is formed in the 2nd path of the above.

[0017] In addition, the injector 27 which carries out injection supply of the fuel is formed in the independent inhalation-of-air path 12 near the suction port. Moreover, the exhaust air port 28 carries out opening to a combustion chamber with each above-mentioned suction ports 21 and 22, and the exhaust valve 29 is formed in this exhaust air port 28.
[0018] 30 is a control unit (ECU) as a control means, and consists of a microcomputer etc. The signal from the throttle opening sensor 31 which detects the opening of a throttle valve, the rotational frequency sensor 32 which detects an engine speed, and negative pressure sensor which detects inhalation-of-air negative pressure 33 grade is inputted into this control unit 30. And while a control unit 30 switches a supercharger operating state to the condition that the condition that only the primary turbosupercharger 5 operates, and both the turbosuperchargers 5 and 6 operate, by outputting the signal which carries out closing-motion actuation of each above-mentioned shutter valves 16 and 17 according to the operational status detected by each above-mentioned sensor, it outputs a control signal to the actuator 26 of the above-mentioned closing-motion valve 25, and closes the closing-motion valve 25 in a low-speed area, and he is trying to open the closing-motion valve 25 in a high-speed region.
[0019] Drawing 2 shows each valve-lift properties IVL1 and IVL2 of the 1st inlet valve of the above, and the 2nd inlet valve 23 and 24 with the valve-lift property EVL of an exhaust valve, and as shown in this drawing, the valve-lift properties of both the inlet valves 23 and 24 differ mutually. The valve-lift property IVL1 of the 1st inlet valve 23 of the above is within the limits whose inhalation-of-air valve-closing time term IC is BDC(after bottom dead point) 60 degree-100 degree, and it is set up so that the valve-opening overlap OL 1 with an exhaust valve 29 may become 20 degrees or less. The valve-lift property IVL2 of the 2nd inlet valve 24 of the above has the large valve-opening overlap OL 2 with an exhaust valve 29 by carrying out an inhalation-of-air valve-opening stage early compared with the valve-lift property IVL1 of the 1st inlet valve 23, for example, it is set as about 35 degrees.
[0020] And by the low-speed area according to which the closing motion valve 25 is closed, an inhalation-of-air valve-closing time term and valve-opening overlap become what is substantially depended on the valve-lift property IVL1 of the 1st inlet valve 23 of the above by control of the above closing motion valves 25, and valve-opening overlap is substantially made large even to the value by the valve-lift property IVL2 of the 2nd inlet valve 24 of the above in the high-speed region where the closing motion valve 25 is opened.
[0021] An operation of such a turbo supercharged engine of this example is explained below, referring to drawing 3 thru/or drawing 6 .
[0022] Since an effective compression ratio will become small compared with this and the work of compression within a gas column will decrease, the expansion ratio which is equivalent to the above-mentioned geometric compression ratio by delaying the closed stage of an inlet valve greatly from a bottom dead point after thermal efficiency was raised and considering as such a high compression ratio being earned if a geometric compression ratio is made into 8.5 or more high compression ratios, compression top dead center temperature is reduced. Knocking is controlled by this. And since a fill can be made to increase by raising the supercharge operation by the turbosupercharger even if blow return of inhalation of air arises by considering as such an inlet-valve ****** condition, if knocking is controlled, the maximum torque restricted by knocking will be raised.
[0023] The mean effective pressure Pe at the time of the maximum torque and the time of MAP 0mmHg changes from such an operation, as shown in drawing 3 by the inhalation-of-air valve-closing time term. That is, while the maximum torque becomes high in the above-mentioned

operation as an inhalation-of-air valve-closing time term becomes late, since the fall of the fill of inhalation of air depended for blowing back is compensated by supercharge, the minimum (Rhine of 0mmHg) of a supercharge region falls in a low load side in a partial load region. Therefore, a supercharge region spreads, so that the delay of an inhalation-of-air valve-closing time term becomes large. If an inhalation-of-air valve-closing time term is set up later than ABDC65 degree for a torque rise, the above-mentioned supercharge region will become large [of the whole region to the maximum torque] to 1/3 or more. In addition, if an inhalation-of-air valve-closing time term is late for ABDC100", compression top dead center temperature will be less than a starting limitation, and it will become difficult to start it.

[0024] About the case where it made the axis of ordinate torque by having made the axis of abscissa into the engine speed, and it considers as the above setup, drawing 4 attaches a slash and shows the supercharge field of 0 or more mmHgs of MAPs. In this drawing, A is Rhine of 4th speed stationary transit.

[0025] At least, as shown in this drawing, if torque sets the range of the supercharge region from T and MAP 0mmHg to the maximum torque to Tc for the range from 0 to the maximum torque in a low-speed area, it would be set up so that it might be set to Tc>(1/3) xT by an inhalation-of-air valve-closing time term fully being delayed as mentioned above, and the supercharge region will be expanded even to the common operation region.

[0026] And although a supercharge field spreads in this way, an NOx reduction operation in a common operation region is effectively acquired by using turbosuperchargers 5 and 6 as a supercharger. That is, if it is a mechanical supercharger, and it becomes a supercharge region, from exhaust gas pressure, a MAP will become high, internal EGR will not be obtained, but if a turbosupercharger is used, internal EGR will be obtained because exhaust gas pressure becomes high also in a supercharge region. For this reason, even if a supercharge region spreads to a common operation region, the NOx reduction operation by internal EGR will be secured in that common operation region.

[0027] Moreover, according to a low-speed area, valve-opening overlap of an intake/exhaust valve is made small at 20 degrees or less, and on the other hand, by enlarging valve-opening overlap of an intake/exhaust valve compared with a low-speed area, torque is raised by exhaust gas back flow depressant action etc. in a high-speed region so that it may explain based on experimental data later.

[0028] further -- this example -- primary , -- since the supercharge response is made to be raised when it has both the secondary turbosuperchargers 5 and 6 and only the primary turbosupercharger 5 operates in a low-speed area, the supercharge engine performance is fully obtained in the field of a low-speed heavy load, and the operation which aims at a torque rise by supercharge, controlling knocking by inlet-valve ****** as mentioned above is attained effectively.

[0029] As drawing 5 showed the inhalation-of-air valve-closing time term with which are satisfied of an operation of NOx control, a torque rise, etc., and the setting range of valve-opening overlap, and the shadow area in this drawing is a setting range in a low-speed area and it already described them It considers as the range whose inhalation-of-air valve-closing time term is ABDC65 degree-100 degree in order to satisfy startability, while securing a supercharge field as shown in drawing 3 and aiming at a torque rise, and since it is exhaust gas back flow control, valve-opening overlap is made into 20 degrees or less. And in a high-speed region, valve-opening overlap is enlarged in the range to about 35 degrees.

[0030] Drawing 6 shows the relation between an effective mean pressure and charge pressure,

and an engine speed about two examples which changed valve-opening overlap of an intake/exhaust valve. In this drawing, the experimental data of the 1st example connected as the continuous line is a thing at the time of making valve-opening overlap into 35 degrees, when a BTDC30" and inhalation-of-air valve-closing time term is made into ABDC60" and it makes [an inhalation-of-air valve-opening stage] ATDC5" a BBDC55" and exhaust air valve-closing time term for an exhaust-valve-opens stage. Moreover, the experimental data of an exhaust valve closing motion stage of the 2nd example connected with the alternate long and short dash line is the same as that of the 1st example, and is a thing at the time of making valve-opening overlap into 35 degrees by making a BTDC15" and inhalation-of-air valve-closing time term into ABDC65" for an inhalation-of-air valve-opening stage.

[0031] As shown in this data, in a low-speed area, if valve-opening overlap is enlarged like the 1st above-mentioned example, torque will fall because the back flow of exhaust gas increases, and torque is raised for the direction which makes valve-opening overlap small like the 2nd example at about 20 degrees. Moreover, when an engine speed is on the high-speed side more than 2000rpm extent, torque will be raised for the direction which makes valve-opening overlap large at about 35 degrees under the effect of the inertia of an inhalation-of-air style etc.

[0032]

[Effect of the Invention] The supercharged engine of invention according to claim 1 Make a geometric compression ratio into 8.5 or more high compression ratios, and a turbosupercharger is used for a supercharger. While an inhalation-of-air valve-closing time term is made into 65 degrees - 100 degrees behind a bottom dead point and a supercharge region occupies 1/3 or more [of the range to the maximum torque] in a low-speed area at least Knocking being controlled by making an effective compression ratio small to an expansion ratio, and reducing compression top dead center temperature, since valve-opening overlap of an intake/exhaust valve is set as 20 degrees or less Although the torque rise by supercharge is achieved and a supercharge region is expanded by this to a common operation region, NOx can be reduced by obtaining internal EGR moderately also in this field. And valve-opening overlap of an intake/exhaust valve is adjusted so that the back flow of exhaust air may not increase, and the torque rise by the low-speed area is attained effectively.

[0033] In this invention, as a turbosupercharger, at least, if it has the turbosupercharger for low speeds in a low-speed area which operates, and the turbosupercharger for high speeds which operates in a high-speed region (claim 2), effectiveness, such as aiming at a torque rise, will be effectively demonstrated by raising the supercharge response in a low-speed area, controlling knocking by the low-speed area as mentioned above.

[0034] Moreover, if overlap of ** and exhaust air is enlarged in a high-speed region compared with a low-speed area (claim 3), in addition to the above-mentioned effectiveness, the torque in a high-speed region will be raised under the effect of the inertia of an inhalation-of-air style etc.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the schematic diagram showing the whole turbo supercharged-engine structure which one example of this invention depends.

[Drawing 2] It is the explanatory view showing valve timing.

[Drawing 3] It is drawing showing relation with mean effective pressure an inhalation-of-air valve-closing time term.

[Drawing 4] It is drawing showing the map of control of valve timing, and control of a supercharge condition.

[Drawing 5] It is drawing showing an inhalation-of-air valve-closing time term and the range of valve-opening overlap.

[Drawing 6] It is the graph which shows the data which investigated the change according to the engine speed of a mean effective pressure and charge pressure about two kinds of valve timing.

[Description of Notations]

1 Engine
3 Inhalation-of-Air Path
4 Flueway
5 Primary Turbosupercharger
6 Secondary Turbosupercharger
23 24 Inlet valve
30 Control Unit (Control Means)